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Adaptive Learning Hybrid Model for Solar Intensity Forecasting

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ABSTRACT: Energy management is indispensable in the smart grid, which integrates more renewable energy resources, such as solar and wind. Because of the intermittent power generation from these resources, precise power forecasting has become crucial to achieve efficient energy management. In this paper, we propose a novel adaptive learning hybrid model (ALHM) for precise solar intensity forecasting based on meteorological data. We first present a time-varying multiple linear model (TMLM) to capture the linear and dynamic property of the data. We then construct simultaneous confidence bands for variable selection. Next, we apply the genetic algorithm back propagation neural network (GABP) to learn the nonlinear relationships in the data. We further propose ALHM by integrating TMLM, GABP, and the adaptive learning online hybrid algorithm. The proposed ALHM captures the linear, temporal, and nonlinear relationships in the data, and keeps improving the predicting performance adaptively online as more data are collected. Simulation results show that ALHM outperforms several benchmarks in both short-term and long-term solar intensity forecasting.

KEYWORDS: SI- TMLM, GABP, adaptive learning hybrid model, EV Charging Station, Multiple Linear Model

I. INTRODUCTION

The has embarked on the ambitious journey of building a digital-model-based smart island emphasizing sustainable growth and environmental stewardship. This initiative involves a broad spectrum of stakeholders, from technology companies to governmental organizations, collaborating to foster innovation and incorporate emerging technologies. The collaborative approach has engendered a conducive ecosystem where the exchange of ideas and expertise thrives, creating advanced solutions tailored to address the island's unique challenges. Both public and private entities have proactively invested resources in research and development, forging strategic partnerships, and launching pilot projects. These concerted efforts aim to ensure the seamless integration of digital modeling technology into the island's existing infrastructure. This infrastructure is envisaged to be further augmented and enhanced with the help of these digital models. In the initial phase, the digital models have been largely employed in energy management, weather information analysis, and performance optimization of renewable energy systems. Employing these models aims to improve the predictability and efficiency of energy production and distribution, optimize the use of renewable energy sources (RESs), and make informed decisions based on accurate weather forecasts. Implementing digital models reinforces Jeju Island's commitment to sustainable growth and environmental protection.

1.1. Multiple Linear Model

In traditional statistical analysis, the multiple linear regression model (MLR) is a fundamental method to quickly generate a linear function between variables and response. It is quite effective in representing a linear relationship, but is not possible to represent any non-linearity. Because it shows fairly strong linearity between solar intensity and some meteorological variables, the overall performance of MLR in predicting solar intensity is acceptable and even good for some sunny days.

1.2. Adaptive Learning Hybrid Model

In the data-based solar intensity forecasting problem, we have built the model exploring different characteristics of the data, including linearity, time series and non-linearity. It is also very important for the model to keep learning online as

more data collected, so that the model becomes more and more accurate. The predicting model should also be adaptive for different places and different time scales, because different places have different climates with different related function between weather variables and solar intensity.

II. LITERATURE SERVEY

2.1. A novel hybrid model for solar radiation prediction

AUTHOR- Smriti Srivastava; Saurabh Bhardwaj; O. S. Sastri

YEAR-2021

DESCRIPTION- Due to the increasing requirement for the design, optimization and performance evaluation of the solar energy systems modeling and prediction of solar radiation is of considerable importance. A number of solar radiation prediction models have been developed, ranging from simple empirical models to very complicated computer coded models. This paper presents Generalized Fuzzy Model (GFM) based paradigm for the prediction of solar radiation. The present research uses both the probability theory and fuzzy set theory for the prediction of radiation. For collecting the meteorological parameters a test bed is made at Solar Energy Centre, Gurgaon, India. Both the models are applied on four different sets comprising of various combination of input meteorological parameters (Day of the year, sun shine hour, ambient temperature, relative humidity and atmospheric pressure). The results of prediction are encouraging.

2.2. Deep-Learning-Based Adaptive Model for Solar Forecasting Using Clustering

Author - SouravMalakar,SaptarsiGoswami

Year-2022

DESCRIPTION- Accurate short-term solar forecasting is challenging due to weather uncertainties associated with cloud movements. Typically, a solar station comprises a single prediction model irrespective of time and cloud condition, which often results in suboptimal performance. In the proposed model, different categories of cloud movement are discovered using K-medoid clustering. To ensure broader variation in cloud movements, neighboring stations were also used that were selected using a dynamic time warping (DTW)-based similarity score. Next, cluster-specific models were constructed. At the prediction time, the current weather condition is first matched with the different weather groups found through clustering, and a cluster-specific model is subsequently chosen. As a result, multiple models are dynamically used for a particular day and solar station, which improves performance over a single site-specific model. The proposed model achieved 19.74% and 59% less normalized root mean square error (NRMSE) and mean rank compared to the benchmarks, respectively, and was validated for nine solar stations across two regions and three climatic zones of India.

2.3. Deep-Learning-Based Adaptive Model for Solar Forecasting Using Clustering

AUTHOR-SouravMalakar, SaptarsiGoswami

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III. PROJECT DESCRIPTION

3.1. EXISTING SYSTEM

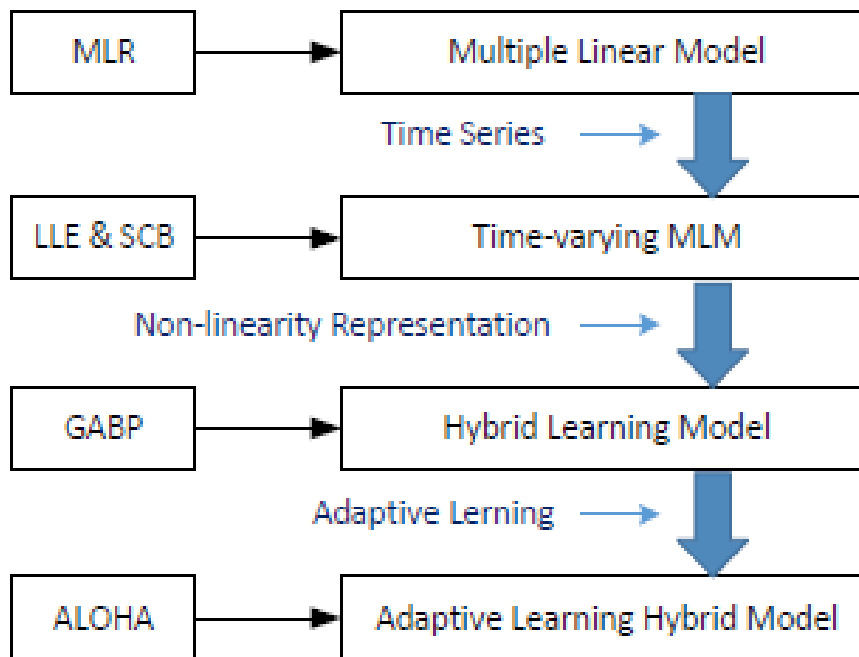
Solar power generation from solar panels are proportional to solar intensity, power generated per unit area. Therefore, predicted solar power can be acquired by predicting solar intensity, which is related to meteorological

variables. Many recent works focus on the meteorological-data-based solar intensity forecasting problem by presenting different methods. The work of [1] provides acceptable predicting results using SVM regression, and the author of [2] proposes the Hybrid Fuzzy Inference System algorithm (HyFIS) as solar intensity forecast mechanism. But it lacks a deep analysis of the solar power generation and weather data. Learning techniques are also used to predict solar intensity, capturing the relationships between solar intensity and the meteorological variables. Artificial neural network (ANN) is also a commonly used learning algorithm for complex function approximation, and it has a group of members, including the Radial Basis Function Neural Network (RBFNN), Back Propagation neural network (BPNN), and the self-organizing neural network (SONN).

3.2. PROPOSED SYSTEM

Adaptive Solar Power Forecasting based on Machine Learning Methods using Due to the existence of predicting errors in the power systems, such as solar power, wind power and load demand, the economic performance of power systems can be weakened accordingly. In this paper, we propose an adaptive solar power forecasting (ASPF) method for precise solar power forecasting, which captures the characteristics of forecasting errors and revises the predictions accordingly by combining data clustering, variable selection, and neural network. The proposed ASPF is thus quite general, and does not require any specific original forecasting method. We first propose the framework of ASPF, featuring the data identification and data updating. We then present the applied improved k-means clustering, the least angular regression algorithm, and BPNN, followed by the realization of ASPF, which is shown to improve as more data collected. Simulation results show the effectiveness of the proposed ASPF based on the trace-driven data.

3.3. BLOCK DIAGRAM



IV. RESULT AND DISCUSSION

Solar power forecasting is critical to ensure the safety and stability of the power grid with high photovoltaic power penetration. Machine learning methods are compelling in solar forecasting. These methods can capture the complex coupling relationship between different meteorological factors without physical modeling. Most of the existing machine learning based forecasts follow the batch learning manner. Once the training is completed, the structure and parameters of the model are usually no longer adjusted. However, the climate is complex and dynamic. It is difficult for a fixed model to adapt to the climate characteristics of different regions or periods. Therefore, an online domain adaptive learning approach is proposed in this paper. Knowledge can be selectively accumulated or forgotten in its

iterative process. As weather changes, the model can dynamically adjust its structure to adapt to the latest weather conditions. Unlike existing adaptive iterative methods, the proposed adaptive learning approach does not rely on the labels of the test data in the updating process. Experiments show that this method can effectively track changes in data distribution and obtain reliable prediction results.

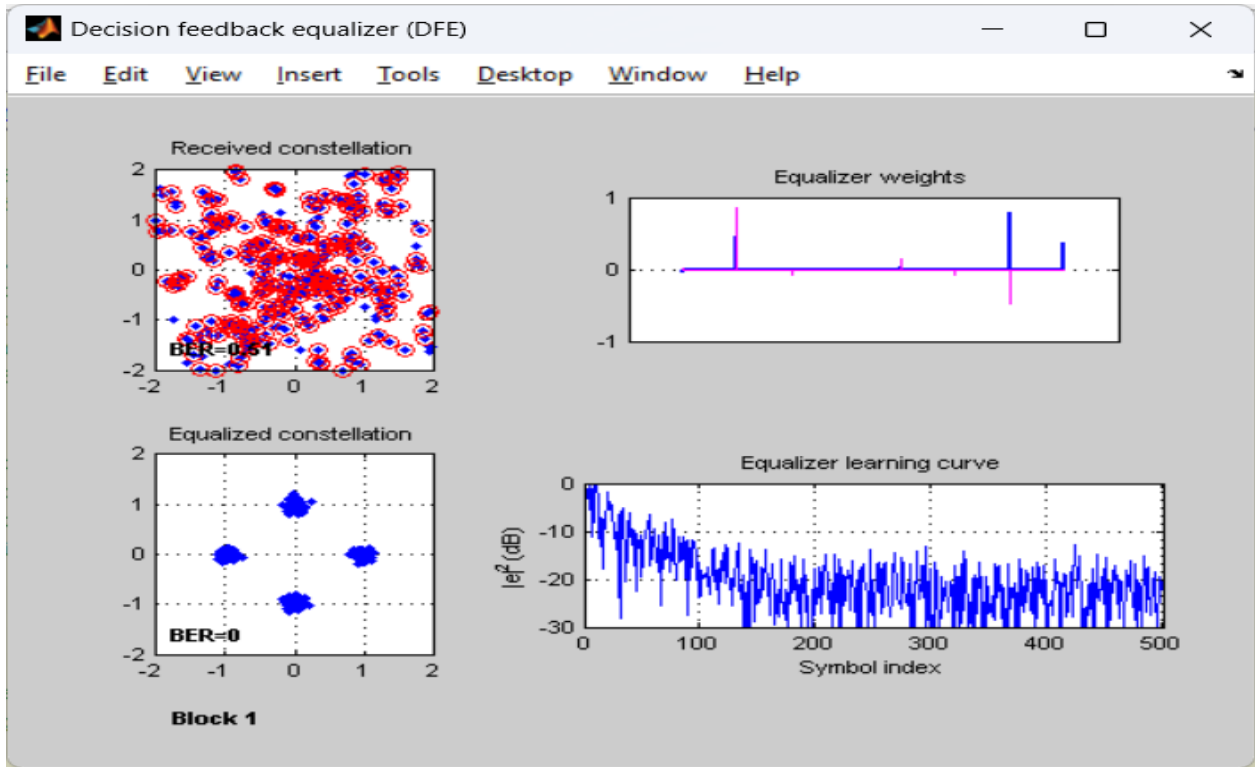


Fig- Self-Organizing Neural Network

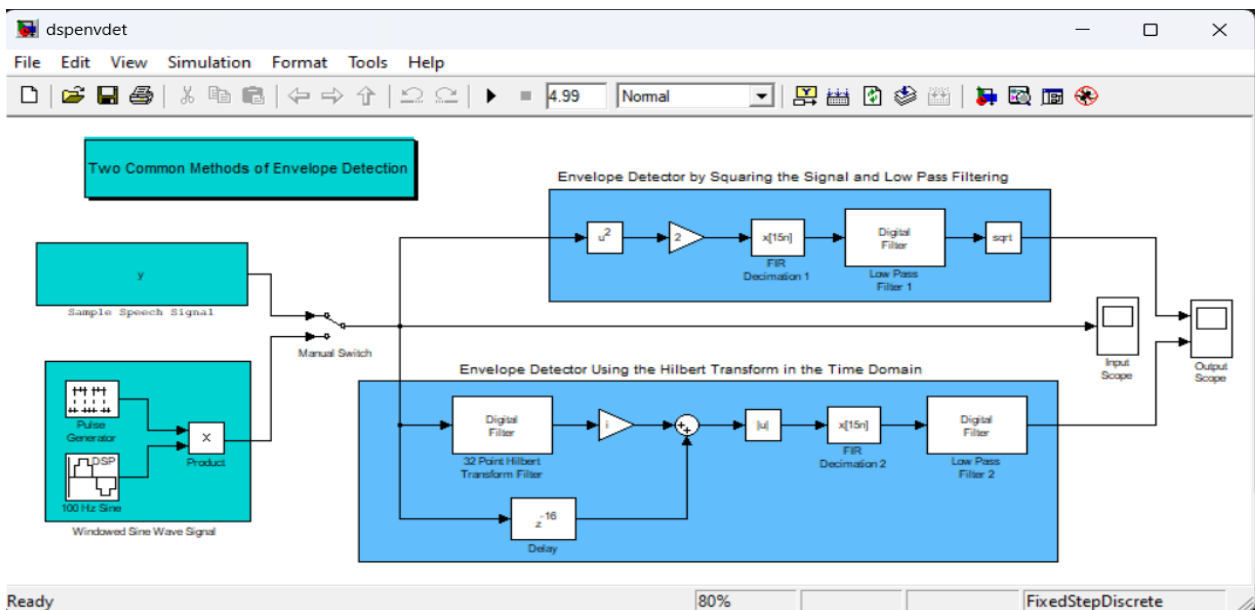


Fig- Construction of the adaptive learning hybrid model.

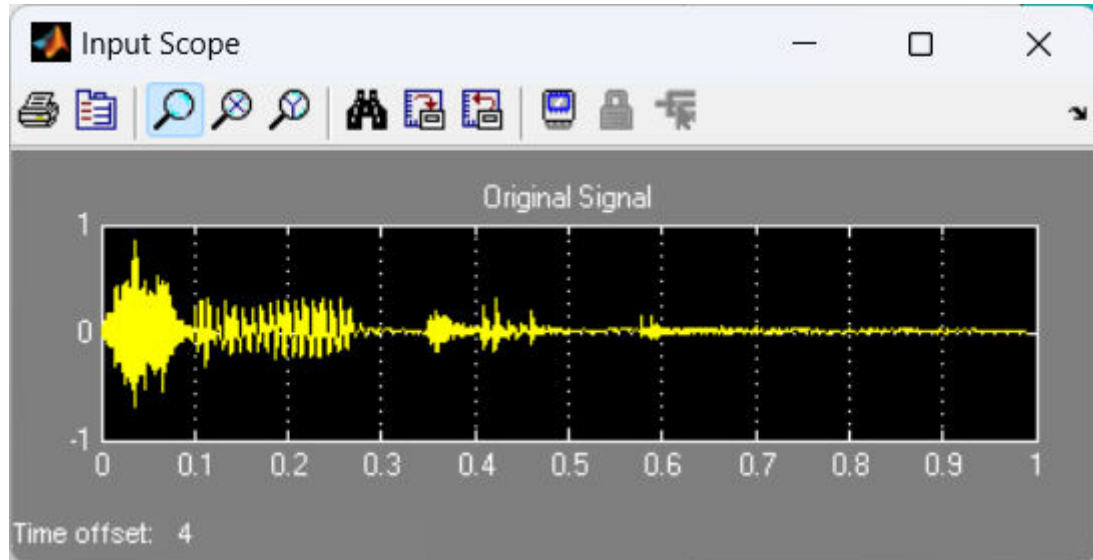


Fig- TMLM-based solar intensity predictions vs. observations

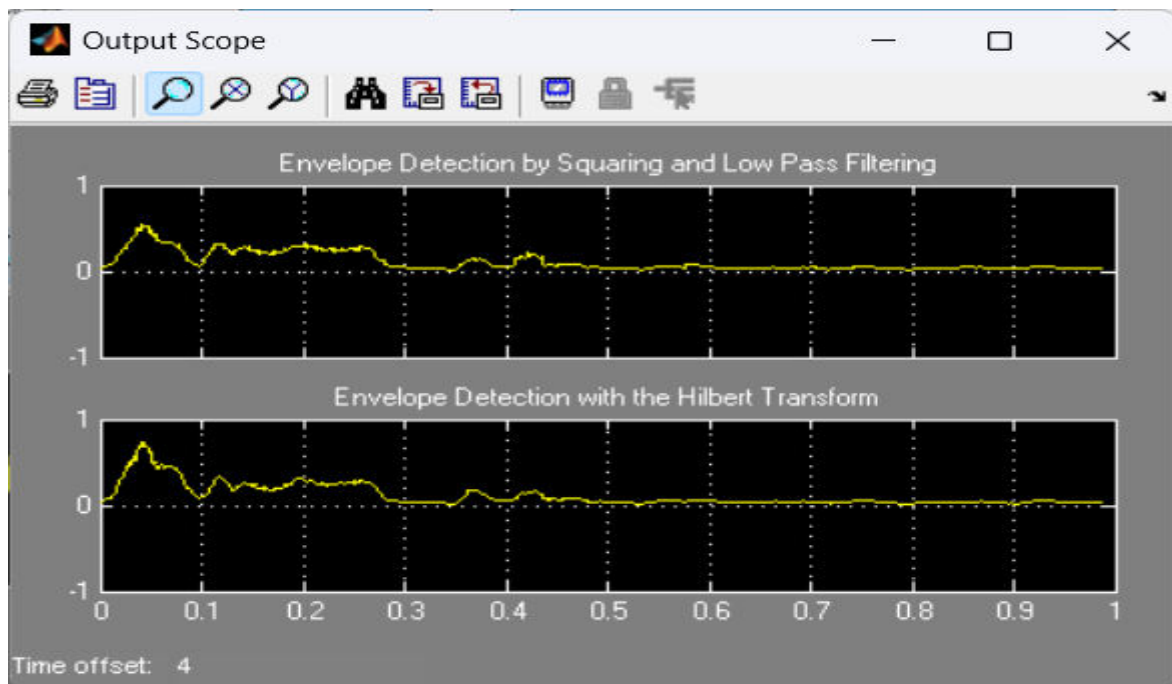


Fig- ALHM-based solar intensity predictions vs. observations.

V. CONCLUSION

In this paper, we developed adaptive learning hybrid model for meteorological-data-based solar intensity predictions. We first presented the fundamental multiple linear model. Then we propose the time-varying multiple linear model and hybrid learning model, which improve the model from the aspects of time series and intelligent learning. We then proposed the adaptive learning hybrid model to learn the nonlinear relationship in the data to further improve the predicting accuracy. The proposed models were validated with trace driven simulations.

FUTURE ENHANCEMENT

In this section, we first introduce the basic linear regression model for predictions from the original statistical formulation. And the general time-varying multiple linear model and learning model are then derived from this, which can improve forecasting precision from the temporal and nonlinear properties of the data respectively. Based on these models, we finally propose the adaptive learning hybrid model. Construction of adaptive learning hybrid model. Therefore, if the linear and temporal factors can be departed from the data, GABP can focus on the remaining nonlinear relationship, and its performance could be further improved as well. In this case, a basic three-layer structure is preferred for faster training and it avoids the complicated process of searching for a suitable structure of the GABP. On the other hand, because of the highly complicated relationship between solar intensity and meteorological variables, it is not possible to capture all the linear and nonlinear relations based on limited amount of data for any method.

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